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Hearing on "Assessing China's Efforts to Become 'An Innovation Society': A Progress Report"

Panel V: Defense Sector Innovation

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by

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Before I turn to my remarks, let me first thank the US-China Commission and today's Co-Chairs for kindly inviting me back to provide some potential insights on the important issue of China's defense innovation. The bulk of my testimony pulls from findings gleaned through a Study Group I chaired last year on behalf of the Study of Innovation and Technology in China (SITC) project at the Institute on Global Conflict and Cooperation (IGCC), University of California San Diego, which administers the Department of Defense's China Minerva program. This Study Group was tasked with determining the contours (if any) of China's concept of a defense innovation system (DIS).[2]

The main conclusion reached by this study is this: China does, indeed, have a sophisticated concept for and is actively working to put in place a new style of modern defense innovation system (DIS). Our study showed that China is in the process of instituting a bold, new, systemic approach to defense innovation that is part of a broad array of organizational, technological, intellectual, and cultural reforms designed to establish a complex, layered, interdependent system-of-innovation-systems (SoIS) model, of which the DIS is only one important part.

China's DIS is, in fact, nested within China's notion of a national innovation system (NIS)[3], which itself departs from the ordinary state-bounded NIS concept in that it incorporates as a core concept a global dimension (i.e., leveraging foreign investments and globally sourced know-how, industrial expertise,

[1] The views expressed here are the author's personal views and in no way represent views of the US Government, US Navy, US Naval War College or any other institution.
[2] Mr. Ed Francis was a co-contributor to this Study Group and co-author of the draft paper presented at the 2011 UCSD/IGCC/SITC conference and workshop. For more on the findings of this Study Group, see Kathleen A. Walsh and Ed Francis, "China's Defense Innovation System: Making the Wheels Spin," Policy Brief No. 23 (September 2011) in *New Perspectives on Assessing the Chinese Defense Economy*, Tai Ming Cheung, ed. (San Diego: IGCC, University of California San Diego 2011). A longer-form book chapter is expected to be published in late 2012/2013.
[3] According to the Organization for Economic Cooperation and Development, "The national innovation systems approach stresses that the flows of technology and information among people, enterprises and institutions are key to the innovative process. Innovation and technology development are the result of a complex set of relationships among actors in the system, which includes enterprises, universities and government research institutes." OECD, *National Innovation Systems* (Paris: OECD, 1997), p. 7.

research and development, and scientific expertise) as well as more micro-level, sub-systems of innovation, including the DIS along with a "knowledge innovation system" (e.g., nationally and/or regionally connected information networks, databases, and scholarly collections), different industry sector innovation systems, region- and industry-specific innovation clusters, and more. This complex, layered system-of-innovation-systems approach is one that reflects lessons learned from other, more innovatively developed states (particularly the United States but also studies of the approaches taken by Canada, Australia, Norway, and perhaps others, as well as reflecting a model proposed by the Organization for Economic Cooperation and Development). China's own approach, however, appears to be a more integrated, interconnected, globally oriented, and complex model suited to China's own aims and aspirations of becoming an indigenously innovative country (see attached chart).[4]

The Chinese approach to developing this innovation-oriented system-of-systems dates back to at least the late 1990s and is outlined and explained most succinctly in a 2006 brief by a senior researcher at the National Research Center for S&T for Development (NRCSTD), which explains that China's NIS concept — in which the DIS is a key part— is designed around the following core components[5]:

- **Enterprises as the innovative center and linchpin** (with the "Defense innovation system combining military and civil use" listed as a subcomponent");
- **Government or state-sponsored research institutes** comprising a "knowledge innovation system" along with universities and colleges;
- **"S&T intermediate service system"** (e.g., investment zones, science parks, incubators, industry associations, technology transfer and product promotion centers, etc.);
- "**Regional innovation system** embodying individual features and advantages" (i.e., the Yangtze River Delta region and other geographically oriented clusters); and
- "**Government system coordinating S&T policies and economic policies**." [emphasis added][6]

Each of these core components is critical to China's efforts to develop its DIS into a more productive, efficient, and advanced source of innovation for military modernization. The first component —placing enterprises at the center of innovative activity— is an obvious first step in today's corporate-dominated global order in modernizing any innovation system, yet has proven particularly difficult in China's experience given the legacy of Soviet-era-like defense industrial development, the continued state-owned enterprise model that largely governs China's defense conglomerates, the limited degree of market-based competition between and among these conglomerates, and more. Current efforts underway to make these enterprises the innovative center of China's DIS include some opening up of the defense industrial sector to private and even foreign investors, plans to continuously reform this sector institutionally in order to regularly shake up vested interests in the status quo that build up over time and reside in the powerful conglomerates, and efforts to make the head conglomerate of each defense industry sector be more involved in cross-industry sector activities —in what some have termed a "matrix approach" to promoting greater defense innovation— in order to foster opportunities that otherwise have and might be missed in cross-industry innovation and entrepreneurship (e.g., aviation and the automotive sector collaborations and potential cross-sector innovations).[7]

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[4] Author interviews with innovation experts in China (December 2011).

[5] Min-Jeong Kim and Jai S. Mah, "China's R&D Policies and Technology-Intensive Industries," *Journal of Contemporary Asia*, vol. 39, no. 2 (May 2009), pp. 264-265.

[6] Gao Changlin, "Chinese Science and Technology Indicators System: Toward an Innovation-Based Nation[s]," presentation to the OECD-MOST Indicator Workshop in Chongqing, PRC (October 19-20, 2006). See also Ed Francis and Kathleen A. Walsh, "China's Defense Innovation System: Making the Wheels Spin," draft conference paper presented to the IGCC "Summer Training Workshop on the Relationship between National Security and Technology in China" (June 20-25, 2011) and the "Workshop on Chinese Military Innovation" (June 28-29, 2011).

[7] "Strive to be a Powerhouse in China's S&T Development – 2010 Annual Meeting of CAS in Beijing," *Bulletin of the Chinese Academy of Sciences*, vol. 24, no. 1 (2010), pp. 1-4.

China's research institutes —whether government-run, university-based, or residing in industry— are also key to the PRC's ongoing development of a nation-wide "knowledge innovation system," a core component in China's strategy to develop a deliberately dual-use innovation model, one intended to simultaneously serve both commercial and defense industrial development goals. This is one of the key areas of weakness in China's past and present efforts to foster greater cross-disciplinary research collaboration and innovation. China's research communities tend still to be isolated from one another, geographically, institutionally, and socially, as do domestic researchers from the growing number of foreign-invested enterprise R&D workers. In order to try to overcome these persistent obstacles, China is working to develop nation-wide and regional information technology resources (networks, databases, and libraries) designed to connect key innovative hubs or technology and research clusters, institutions, and other actors, sharing research results electronically and promoting greater use of government-funded research for defense and commercial purposes. The linking up electronically and otherwise of these various centers of innovation across China is part of a broader, ongoing "grid approach" that seeks to connect the country's geographically and institutionally dispersed research communities, making each a key node in a national, inter-connected, knowledge-based, dual-use innovation system.[8]

One of the most important components in China's SoIS approach to modernizing its DIS is the third, so-called "S&T intermediate service system" (which refers to China's array of different sorts of investment zones, science parks, incubators, industry associations, technology transfer and product promotion centers, etc.). This component represents all the various experimental investment, innovation-promoting, and technology transfer efforts and services China has been attempting and perfecting over the past 20 years of reform aimed at hastening and advancing economic development, particularly in the commercial sector. This same approach is now being applied to the defense sector, with the recent emergence of defense industry- and civil-military-specific investment zones, S&T parks, technology promotion centers and related activities geared toward hastening, advancing, and socializing defense sector technologies, expertise, and innovations. In short, having found that many of these efforts have succeeded, at least in part, in the commercial sphere to prompt more innovative and entrepreneurial activity, Beijing is adopting a similar service-oriented approach now for the defense sphere. It is not clear, however, whether these sorts of S&T- and innovation-friendly services will have the same effect on the defense sector as on the commercial, which benefited from what a World Bank report termed industrial "Plug and Play" zones that allowed small and medium-sized enterprises as well as foreign investors to more readily compete in there area or regional markets and become part of developing technology clusters.[9] Whether or not China's private-sector, smaller-size enterprises can compete with or adequately supply China's large-sized defense conglomerates in a similar way remains to be seen, although it appears that some progress is being made in this regard.

The fourth component is also critical to China's efforts to establish a more modern and productive DIS. As in the commercial realm, China's strategy over the past several years has been to promote regional innovation systems (RIS), based on the industrial, geographic, technological, and other particular assets and characteristics of each particular region of China. This is an effort to prevent nearby provinces, municipalities, and local areas from competing with one another for the same domestic and foreign resources and investors (leverage that foreign investors can and have exploited in the past) as well as to pursue Beijing's top industrial, scientific, and technological objectives in a strategic, distributed fashion. So, for instance, Shanghai will dominate development of certain strategic industry sectors such as automotive, shipbuilding, and biotechnology, while other regional zones and innovation systems will concentrate on information technology, aerospace, energy or other strategic sectors prioritized by central authorities. Three new economic zones that will serve as separate regional investment zones, innovation

[8] CAS Bulletin (2010).

[9] In a fascinating study comparing the success or failure rate of investment zones in China, Vietnam and Ethiopia, this study found that China's "Plug and Play" industrial and investment zones played a vital role in China's comparative success. See Vincent Palmade, Hinh T. Dinh, Vandana Chandra, "China's secret weapon in light manufacturing: Small and Medium Enterprise-oriented 'Plug and Play' industrial zones," World Bank blogs (November 29, 2010), accessed online at http://blogs.worldbank.org/developmenttalk/node/569.

systems and technology clusters have been approved in recent years, one in particular with important implications for the defense sector. Under the 11th Five-Year Plan, the three new regional zones are the Chengdu-Chongqing Economic Zone (CCEZ), which is important in that it includes the traditional Third Line defense enterprises and Mianyang research area; the Guanzhong-Tianshui Economic Zone or "West Triangle Economic Circle"; and the Beibu Gulf (Guangxi) Economic Zone (also referred to as the "Little Beibu Gulf" and encompassing Beihai, Qinzhou, Fangchenggang, Nanning, Changzuo, and Yulin).[10] Each focuses on certain industry and high-tech sectors but at the same time is expected to increasingly be connected to and, authorities hope, collaborating innovatively with other zones, clusters, and regional innovation systems across the country via, among other means, the information-sharing grid approach noted earlier. In this way, authorities seek to increase access of still-centrally located defense researchers, academics, enterprises, and others to the more economically and innovatively vibrant coastal areas; the latter, in turn, will have greater access to potential dual-uses of defense research taking place in central and western parts of the country.

The fifth component addresses the changing view of the role of government in China's innovation strategy. Though subtle, there has been a clear shift in thinking over the past decade in terms of what role central authorities should take when it comes to promoting innovation. Today's view is that the most productive role for government in such cases is to serve more as stated in the NIS model: as lead coordinator, providing the necessary strategic, long-term guidance to key actors and institutions, but without getting into the particularly quantitative mandates and micro-managing so often witnessed in past decades. The hope is that this more flexible approach on the part of government authorities will allow prospective innovators a freer hand as to how exactly they see fit to pursue innovative opportunities supported, guided, and prioritized by the state. Old habits are hard to break, however, particularly in a still largely centrally planned economy and politically authoritarian structure. Although the number of rules, regulations, catalogues, and other government policy documents have not lessened, the language and tenor used in promoting state aims has to some degree reflected this newer tone and approach to government as coordinator and strategic guide versus implementer of mere mandates and quotas. Only time will tell, however, whether this new approach will truly take hold, particularly at lower levels of government authority (i.e., provinces, municipalities, villages, and townships) and accepted among innovators themselves. It is important to note, however, that recent studies comparing progress across different national innovation systems find that states possessing both strong top-down strategic guidance on innovation as well as a robust, organic, bottom-up innovative dynamic fare better than those reliant on either one or the other foundation.[11] Chinese authorities today support both approaches, with a particular focus at present on spurring the bottom-up dynamic through a focus on incentivizing and enhancing civil-military, cross-disciplinary, and other cross-cutting relationships among China's innovative communities.

Taken together, these five components comprise China's basic strategy for establishing a more modern and robust DIS, as a key part of China's overarching NIS, and one that is integrated with the various other levels of innovation systems simultaneously being pursued. In this way, China's approach bears a striking resemblance to that portrayed by the OECD in a study outlining the notion of an NIS published in 1999. Yet China's concept also has interesting and distinct features, including the deliberately dual-use nature of China's model.[12] Also, while some states' NIS might focus primarily, if not exclusively, on promoting domestic linkages, China's NIS *and* DIS both emphasize international linkages as a core element.[13] Both distinctions fit the pattern of China's past strategic development plans that, despite much

[10] Francis and Walsh (2011).
[11] Royal Society (2011); and NRC (2010).
[12] OECD, *Managing National Systems of Innovation* (Paris: OECD, 1999).
[13] The original notion of an NIS as depicted by Freeman did presume national boundaries, although this has since been the subject of much debate. See Chris Freeman, *Technology Policy and Economic Performance: Lessons from Japan* (London: Pinter, 1987); and Judith Reppy, "Competing Institutional Paradigms: Conceptualizing the Role of Defense Industries in National Systems of Innovation," in Judith Reppy (ed.), The Place of Defense Industry in National Systems of Innovation (NY: Cornell University Press, 2000), p. 1. Others have termed China's approach more of a "Global Innovation System," suggesting China abandoned the borders-limited NIS model in the early 1980s. See Jon Sigurdson, "Regional Innovation Systems (RID) in China," Working Paper 195 (July 2004), p. 5, accessed online at http://swopec.hhs.se/eijswp/papers/eijswp0195.pdf.

Western criticism, persist in attempting to establish an "indigenous innovation" capacity, in large part by leveraging foreign technology transfers, and to spin-off as well as spin-on civil-military technological advances, despite the technological, institutional, time-consuming, and cost-factor difficulties inherent in this approach. As such, China's pursuit of a DIS as nested within its NIS appears in important ways to depart from more traditional notions of what constitutes an effective NIS and DIS but represents a new stage in China's ongoing innovation efforts.

The key reason why China's bold ambitions in this instance are worth taking seriously is the reality of an increasingly global S&T phenomenon that is taking place simultaneously. The evolution of globalization has reached a new stage. Prompted initially by cheap, fast, mobile information communications technologies and networks, the current wave of globalization rapidly took hold in the developed and developing worlds over the past two decades, concurrent with China's economic growth. In turn, this led to commercial outsourcing and then global offshoring of industrial assembly and corporate manufacturing, services and marketing. As the latter processes matured, the demand for globally located commercial R&D activities took hold and has become a globally resourced endeavor, China being a leading foreign R&D investment location among still-developing countries. The final stage in this story, it appears, is also now being told, as science itself becomes an increasingly global, competitive endeavor that is likely to lead over time to the same market-oriented, nation-based, competitive advantage dynamics that we've seen in the other stages of industrial globalization.[14] In short, scientific research and the innovations or inventions it might spawn, as well as the scientists and innovators themselves are increasingly mobile and globally dispersed –including in China, who is actively courting international scientific resources, foreign universities, fellows, and scholars to serve its dual-use innovation ambitions. The question then arises: can or will China in time become as, or an even more, appealing and/or competitive market for scientific and innovative undertakings than the United States? The question holds obviously important implications for US national security interests and for US-China relations.

Implications for US National Security and Policy

Given China's ambitious innovation aims and activities, including in the defense realm, the United States can decide among a number of options. The temptation, of course, will be to try hold back China's innovative capacity via denial of US and, to a likely increasingly ineffective extent in such a globalized age, allied inputs. Yet given the scope and scale of China's increasingly worldwide reach and its fast-expanding scientific, technological, industrial, and scholarly ties across the globe, this seems a flawed approach that is more likely to produce diminishing returns over time than strategic gains, since any hope of containing China's access to non-military scientific, technological, industrial or otherwise intellectual knowledge is an increasingly fool's errand in today's globalizing environment and could do more to isolate the United States from global S&T dynamics than to undermine China at this stage. As such, the risk in doing so now arguably outweighs that of engaging strategically, if selectively, with China on such matters. Another option, often the default, is to do nothing. This, too, would be unwise, as it risks US innovators falling behind growing international S&T competition. What, then, to do? The practical, if not optimal, answer from a US national security perspective would be to find ways to better leverage China's (and other developing states') growing openness, support of, and access to the world's scientific, technological, industrial, and otherwise intellectual assets. This can only be achieved, however, via engaging with China and others on matters of S&T, something the United States has long done well and from which our national security enterprise has prospered tremendously over the past half century. Along these lines, it is heartening to see that the Defense Science Board has begun to think in part about this issue, as suggested in the January 2012 report by the Task Force on Basic Research in a global S&T age.[15] But much more strategic thinking is needed on this topic of what the United States' S&T development

[14] See Royal Society, *Knowledge, Networks and Nations: Global Scientific Collaboration in the 21st Century* (London: The Royal Society, 2011); and Committee on Global Science and Technology Strategies and their Effect on US National Security, *S&T Strategies of Six Countries: Implications for the United States* (Washington, DC: National Academies Press, 2010).

[15] Office of the Under Secretary of Defense for Acquisition, Technology and Logistics, *Report of the Defense Science Board Task Force on Basic Research* (Washington, DC: US Department of Defense, 2012), online at www.acq.osd.mil/dsb/reports/BasicResearch.pdf.

and innovation strategy and policy will be in a world of globalizing S&T where China is an increasingly central player if we hope to stay ahead of China's innovative ambitions in the defense realm and otherwise.

As outlined in a recent study by the United Kingdom's Royal Society, today researchers and scientists increasingly collaborate across international boundaries and on projects that involve individual, non-state, state, and multi-state scientific cooperation, essentially working on scientific and technological challenges wherever they find the best talent, infrastructure, and institutional or government support. As a result, every step on the innovative ladder —from concept development and basic scientific research through applied R&D to technology development and marketing and other innovations— has been to a growing degree outsourced, offshored, or is increasingly available through international collaboration, with the important exception of select secret defense and weapons research. This new paradigm is one that China and others seek to exploit in pursuit of their own national and defense innovation systems; it is one the United States must continue to pursue strategically, including with regard to China.

Conclusion:

China's bold approach to developing a vibrant, 21st century DIS is by design dependent upon the success (or failure) of the other systems-of-innovation-systems that make up its complex, layered design. For China, this could prove to be a disastrously ambitious endeavor. Yet, given the nature of innovation, which appears to thrive on just the sort of laissez-faire, interconnected, cross-cutting, interdisciplinary, and entrepreneurial *ecosystems* that China is seeking to put in place across the country and has had a degree of success in doing for the commercial sector, these efforts hold the potential to prompt much more innovative results from Chinese industry, including from the defense sector in the years to come. China's present approach to fostering defense and related innovation suggests a new degree of strategic patience, indicating that Beijing feels time is on its side, allowing China to take a more fundamental, bottom-up approach to devising a more effectively innovative system-of-innovation-systems model (rather than rushing to leap-frog technology advances when- and wherever possible, although this approach is likely to persist in certain high-priority areas). If so, this would portend for the short-term a greater likelihood of incremental and product innovations, particularly where it serves to fill critical capability gaps in China's commercial and defense sectors. Perhaps this accounts for some of the more recent advances coming out of China's defense sector, such as the new classes of submarines, ships, and missiles, the J20 stealth fighter prototype, and other recently unveiled defense technologies and capabilities. According to Pentagon experts, "Defense industry modernization accelerated in the mid-1990s based on reforms to rationalize military procurement and increase innovation among China's state-owned defense companies. These reforms have enabled the development and production of select weapon systems, such as missiles, fighter jets, and warships, approaching performance parameters comparable to Western systems."[16] Over the longer-term, if this more fundamental approach to innovation continues and effectively takes hold (notably, two big "ifs"), it could signal a new ability by China over time to innovate in more advanced ways, both in terms of process innovation and possibly even more radical forms of innovation.

For the United States, the question remains: what are we going to do vis-à-vis China's efforts today to establish this bold SoIS model to ensure that the US defense sector, in particular, is even more innovative in a global science, technology and industrial age, both in the near and long term? If ignoring or in some limited way containing China's S&T and innovative reach are not viable strategic options, then what *is* an appropriate strategy? There are no simple answers to this complex question. But it is imperative that this question be tackled, and a US innovation strategy for a globalized S&T environment in which China plays an increasingly important role in the 21 century be articulated.

[16] See US Department of Defense, *China Military Power* (2007), pp. 26-27 online at http://www.defense.gov/pubs/pdfs/070523-china-military-power-final.pdf; and Francis and Walsh (2011).